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(54) Title: METHOD OF MANAGING AND MARKETING LIVESTOCK BASED ON GENETIC PROFILES

(57) Abstract: A method of managing and marketing a group of commercial animals, such as cattle, based on a predetermined genetic profile includes the steps of determining, prior to entry of an animal into a feedlot, a genotype of a subject animal with respect to genetic markers for selected ones of at least the traits for growth, quality grade, yield grade, marbling, rib-eye muscle area, dressing percentage and meat tenderness, and feeding the animal utilizing criteria based on the genotype of the animal. The animal is grouped with other animals into a subgroup having either a defined genotype, a similar animal economic value or a common market endpoint, and the subgroup is assigned to a pen. The subgroup is managed, fed, slaughtered and marketed according to the genotypic profile for the subgroup. The animal is fed each day a ration having a quality determined by using a biological model of potential growth based on the genotypic profile of the animal. Weight and breed data of the animal are gathered at entry into a feedlot, and are used along with the biological model to predict an amount of growth of muscle and fat tissue for each of a plurality of hypothetical rations fed for respective hypothetical periods of time. A net value of the animal is estimated using a bioeconomic model along with at least a cost of feed ration, predicted yield and quality, and corresponding market price. An optimal time to send the subgroup to slaughter is determined based on at least the net value estimated using the bioeconomic model. Subgroups having a genotype corresponding to an undesirable genotype are identified and are managed differently.

METHOD OF MANAGING AND MARKETING LIVESTOCK BASED ON GENETIC PROFILES

BACKGROUND OF THE INVENTION

The present invention relates to a method of managing and marketing cattle based on genetic profiles. In particular, the invention relates to a method of managing and marketing cattle by grouping the animals according to their individual genotypes and managing, feeding and slaughtering animals as a uniform group according to the quality and yield attributes corresponding to the group.

Beef cattle are currently managed and traded as a commodity primarily because value differences in live animals that are due to the inherent genetic variation in the yield of tender and marbled beef from their carcasses cannot be determined. Packers are forced to sort through thousands of carcasses of animals slaughtered each day in order to identify those that meet the specifications of their customers. Due to the very high daily volume of slaughtered animals and limited cooler space (which reduces ability to sort), packers are unable to efficiently market their inventory based upon quality specifications. Further, packers have no ability to discriminate among the carcasses that do not grade choice that could be marketed as a tender product. By and large, the variation in product specifications that the packers must manage each day correlates directly to the variation in the cattle received.

Feedlots market to the packers pens of cattle that have been fed to an "average" endpoint. This endpoint is influenced by the extent to which the feedlot was able to sort the cattle in each pen prior to beginning feeding and the number of days that the pen was on feed. Typically, a feedlot pen has a capacity of 200 animals which reflects the annual production of at least 5 different cow-calf producers. As cattle enter the feedlot, they are sorted according to estimated weight and apparent breed characteristics. Cattle with black coat color or that appear to be of British breeding are grouped differently than cattle which appear to have a high degree of Brahman breeding. Similarly, cattle that appear to possess a high degree of continental European breeding are segregated. This grouping reflects knowledge that cattle of British breeding tend to produce beef that is more highly marbled and tender than beef from Brahman influenced cattle. It also reflects knowledge that the beef yield from cattle of continental European breeding is greater, but the extent of marbling is less, than that from cattle of British breeding.

Cattle within a pen are fed to an endpoint that is intended to maximize the percentage of animals that will grade USDA Choice at slaughter with a target weight endpoint of 575 kg without incurring severe price penalties due to a high percentage of excessively fat, underweight or overweight cattle. Grouping of cattle prior to feeding is intended to minimize variation in final weight and USDA Quality and Yield Grades. However, grouping based on initial weight and apparent breeding is compromised by the fact that there is as much genetic variation in growth potential, carcass yield and quality attributes within breeds of cattle as exists between breeds.

SUMMARY OF THE INVENTION

It is an objective of this invention to provide a method of managing and marketing a group of commercial animals, such as cattle, to comply efficiently with quality and yield specifications.

Another objective of this invention is to provide a method of managing and marketing the animals efficiently according to the genotypes of the animals with respect to genetic markers for selected ones of at least the following traits: growth, quality grade, yield grade, marbling, rib-eye muscle area, dressing percentage and meat tenderness.

The present invention, in accordance with one embodiment, provides a method of managing a group of commercial animals based on a predetermined genetic profile, comprising the steps of (a) determining for each of the animals in the group a genotype of such animal with respect to genetic markers for selected ones of at least the following traits: growth, quality grade, yield grade, marbling, rib-eye muscle area, dressing percentage and meat tenderness, (b) forming subgroups of the animals, wherein each subgroup has a defined genotypic profile, and (c) managing each subgroup utilizing criteria based on the genotypic profile for that subgroup.

The present invention, in accordance with a preferred embodiment, provides a method of managing a group of commercial animals based on a predetermined genetic profile, comprising the steps of (a) determining for each of the animals in the group a genotype of such animal with respect to genetic markers for selected ones of at least the following traits: growth, quality grade, yield grade, marbling, rib-eye muscle area, dressing percentage and meat tenderness, (b) forming subgroups of the animals, wherein the animals in a subgroup

have approximately the same economic value, and (c) managing each subgroup utilizing criteria based on a genotypic profile for that subgroup.

The commercial animals may be cattle. The genotype of each animal is determined prior to entry of the animal into a feedlot.

The method further may include the step of identifying from within the group one or more subgroups having a genotypic profile that includes an undesirable genotype. The undesirable genotype may be unacceptably tough meat.

Each subgroup is fed each day ration having a quality determined by using a biological model of potential growth based on the genotypic profile of the subgroup.

The method further may include the step of predicting an amount of growth of muscle and fat tissue for each of a plurality of hypothetical rations fed for respective hypothetical periods of time, using a biological model based on at least the genotypic profile of the subgroup. The method further may comprise the step of gathering weight and breed data of each animal in each subgroup at entry into a feedlot, wherein the weight and breed data are used along with the biological model to predict the amount of growth of muscle and fat tissue.

The method further may comprise the step of estimating a net value of the subgroup, by using a bioeconomic model including a cost of fed ration, and predicted yield, quality and market price. The method further may include the step of determining an optimal time to send the subgroup to slaughter, based on at least the net value of the subgroup estimated using the bioeconomic model.

Each subgroup may be fed a ration a number of days that is determined by using a biological model of potential growth based on the genotypic profile of the subgroup. Animals in at least one subgroup may be treated with a growth promoting implant determined by using a biological model based on the genotypic profile of the subgroup. Animals in at least one subgroup may be fed a ration that includes additives determined by using a biological model based on the genotypic profile of the subgroup. Animals in at least one subgroup may be subjected post-slaughter to at least one of an electrical stimulation and a mechanical tenderization process determined based on the genotypic profile of the subgroup.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and numerous other objectives, features and advantages that may be achieved by the present invention would be more readily understood from the following detailed description by referring to the accompanying drawing wherein:

FIG. 1 shows a flow chart of a process for managing and marketing cattle, in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Knowledge of an animal's underlying genetic predisposition to yield marbled and tender beef allows the stratification of the existing commodity market to facilitate the management and marketing of animals based upon product specifications. As much as 50 percent of the variation in growth, carcass yield and quality attributes in cattle is determined by the additive effects of genes. The remaining variation is due to (1) the environment that an animal is exposed to prior to entry to the feedlot and (2) management of the animal receives during the feedlot and slaughter phases of production. Thus, at least 50 percent of the variation that currently exists within the commodity cattle market could be eliminated by grouping cattle according to their individual genotypes at entry into the feedlot. These animals then could be managed, fed and slaughtered as a uniform group and marketed according to their quality attributes. This technique allows the creation and marketing of new "branded" products, such as lean and tender beef.

Determination of the location and effects of genes which are responsible for variation in growth, carcass quality and yield has been accomplished through the use of a series of genome scans in different breeds of cattle. In each genome scan, the parents and progeny defining a set of families are genotyped for a series of DNA-based markers which span the entire genome. The class of DNA marker utilized in the scan is not important and the marker polymorphisms detected do not have to represent the causal mutations in the genes, promoters or enhancers (collectively denoted "genes") responsible for the variation in growth, carcass quality and/or yield. Typically, only the progeny are slaughtered and data are gathered on these animals to characterize their phenotypes for growth, carcass quality and yield. The genotype and phenotype data are then analyzed statistically to reveal the chromosomal locations and the magnitude of effects of the genes responsible for variation in growth, carcass quality or yield. The presence of a gene responsible for variation in any

phenotype is only validated by its detection in at least two families within or between genome scans. Finally, the allelic form of the gene is detected by the construction of haplotypes based on multiple markers within the region of the chromosome that harbors the gene. Each haplotype provides a unique diagnostic "fingerprint" of each chromosome in an animal and is predictive of the animal's underlying genetic architecture at the causal gene even though the identity of the gene may not be known. It has been shown that widespread disequilibrium exists within the cattle genome and this ensures that haplotypes based upon closely linked markers are predictive of genotype at a causal gene.

F. Ruvuna, J. F. Taylor, J. P. Walter, J. W. Turner, and R. M. Thallman, "Bioeconomic Evaluation of Embryo Transfer in Beef Production Systems: I. Description of a Biologic Model for Steer Production," J. Anim. Sci. 70:1077-1083 (1992) describes a deterministic model for evaluating embryo transfer for commercial steer production taking into consideration genetic merit for growth and mature size, herd feed supply, and recipient maternal environment. F. Ruvuna, J. F. Taylor, J. P. Walter, J. W. Turner, and R. M. Thallman, "Bioeconomic Evaluation of Embryo Transfer in Beef Production Systems: II. Economic Evaluation of Steer Production," J. Anim. Sci. 70:1084-1090 (1992) describes a bioeconomic model for evaluating economic implications of embryo transfer for steer production. F. Ruvuna, J. F. Taylor, J. P. Walter, J. W. Turner, and R. M. Thallman, "Bioeconomic Evaluation of Embryo Transfer in Beef Production Systems: II. Economic Evaluation of Steer Production," J. Anim. Sci. 70:1084-1090 (1992) describes a model for economic evaluation of embryos for producing bull lines for use in commercial beef production.

The grouping of animals for feedlot management and subsequent marketing is accomplished through the analysis of diagnostic DNA fingerprints using a computer-based bioeconomic model that estimates the economic value of the animal according to prices associated with quality, yield and growth efficiency and the variable costs associated with production. The animals are managed according to their economic value to the feedlot. An economic value is assigned to each animal using the bioeconomic model. The animals may be ranked from highest to lowest and assigned to management groups (feeding pens) based on their value. For example, a predetermined number of the highest valued animals may be assigned to the first pen and a predetermined number of the lowest valued animals to the final pen, etc. The bioeconomic model may be highly nonlinear and emphases placed on different

characteristics to reflect market realities. For example, if the market determines that meat tenderness should dominate the value differences in beef, then the bioeconomic model would rank animals according to their genotypes at the genes responsible for differences in meat tenderness.

Prior to feedlot entry, animals are genotyped to determine their architectures for genes known to influence variation in growth, carcass quality and yield. In conjunction with each animal's weight and breed characteristics gathered by the feedlot at entry, the animal's genotypic data are used in a computerized biological model to predict the animal's growth of lean muscle and fat tissues as the animal is fed a series of alternate rations, selected by the feedlot, for a variable number of days. The animals in each of the pens may be fed a ration *ad libitum*. The animals in a feedlot typically are not individually fed. Therefore, the amount of feed that an individual animal eats is estimated in order to model the cost of production of growth. Individual animal feed intake is accounted for in the economic model to assign a value difference to two animals that have different genetic potentials for growth.

The quality of the rations, i.e. as determined by the energy and protein contents, and thus the cost, of the components of the ration, fed to corresponding different pens differ. The biological model estimates the amount of each ration that should be consumed by the animal on each day in order to support the animal's genetic potential for growth. The rate of development of muscle and fat tissues is predicted from the genotype of the animal. The net energy and protein requirements of the ration that will allow the animal to achieve the predicted rate of development (accretion) of muscle and fat tissues is determined. Thus, the animals with the highest muscle and fat growth rates are fed a diet in which energy and protein are more concentrated than the ration fed to animals with lower rates of muscle and fat development. The more concentrated diet typically is more expensive than the less concentrated diet. The feedlot's objective is to get each animal to its maximum economic value. A single ration is fed to animals in a pen from the start to the end of a feeding period. Thus, after the model ranks the animals for their profitability and assigns each animal to a management group, the ration will be the same for all of the animals within a group, but it may differ in quality from group to group. The net value of each animal on each day of feeding is estimated based on the cost of the fed ration, the predicted yield and quality of the carcass and the current price differentials for cattle of different USDA Quality grades.

There may be a number of different genotypes that are desirable and a number that are undesirable. The cattle that are predicted to produce unacceptably tough beef, for example, may be identified based on their genetic fingerprints. Such animals may be identified for management interventions targeted to improve the tenderness of their beef. For example, the identified animals may be given a vitamin E supplement to their diets or a high voltage electrical stimulation post-slaughter, and/or the beef from the animal might be mechanically tenderized or marketed differently. Perhaps the high priced loin cuts might be harvested and mechanically tenderized, while the remaining meat on the carcass would be harvested and fabricated into ground beef (e.g., for hamburgers).

Based upon the capability of the feedlot to manage pens of cattle differentially, the model provides an assignment of cattle to individual pens and a recommendation for the optimal number of days on feed to maximize net return and optimize the uniformity of carcasses from the pen. This strategy allows the feedlot to market pens of cattle possessing uniform carcass specifications which can be grouped and fabricated as a branded product. The animals in a pen may be marketed as a group, but to different buyers.

To explain further the invention, we describe some embodiments in connection with the drawings and their supporting descriptions provided below.

A method of managing a group of commercial animals based on genetic profiles, in accordance with an embodiment of the present invention is shown in FIG. 1. Genotype and phenotype data are gathered and analyzed, and genetic architectures for selected ones of at least the traits for growth, quality grade, yield grade, marbling, rib-eye muscle area, dressing percentage and meat tenderness of the animals are determined in step 101. The association between a genotype and a phenotype is determined. For example, there are two alleles corresponding to one of the genes responsible for variation in the trait of beef tenderness, one that enhances tenderness (the t^+ allele) and one that reduces tenderness (the t^- allele). A t^+t^+ animal will produce beef that has a 1.0 kg lower Warner Bratzler shear force, on average, and therefore is more tender, than an animal with a t^-t^- genotype.

Biological and bioeconomic models are developed in step 102 for genotypes represented by the corresponding genetic architectures determined in step 101. The models capture both the biology and economics of the production system within which the animals are managed. Step 102 also includes defining the management and marketing options, which

may differ from one feedlot to another, for each group of animals. The data and models compiled in steps 101 and 102 are used for managing and marketing individual and groups of animals.

The genotypes of a plurality of animals are determined in step 103, prior to entry of the animals into a feedlot. At entry of the animals into the feedlot, weight and breed data are gathered in optional step 104. The accuracy of the bioeconomic model is significantly increased if the weight and breed type of the animal entering the feedlot are known. For example, a genotype may tell us that an animal has a high genetic potential for growth. However, the accuracy of an evaluation of the economic value of the animal and consequently how to group that animal may depend on if the animal is 150 kg or 350 kg when it enters the feedlot. Further, if two animals have the same genotype for marbling with one being Angus and the other being Brangus (a composite of Brahman and Angus), the Angus animal would achieve a higher overall marbling score, on average, than the Brangus animal due to the genetic background of the two animals.

In step 105, the economic value of each animal is estimated using a bioeconomic model based on the animal's genotype, weight and breed data, and the animals are ranked based upon estimated economic value.

In step 106, assign the animals to management groups, preferably based upon their economic value rankings. Each subgroup may have a defined genotypic profile. For example, a feedlot may comprise pens of cattle, each having about 200 animals. According to the economic rankings, the first 200 highest ranked animals are assigned to the first pen, the next 200 highest ranked animals to the second pen, and so on until all animals are assigned to pens. There may be, for example, 500 pens of cattle in a large feedlot having the capability to control the number of days on feed for each of these pens according to the recommendation of the bioeconomic model. However, the feedlot may have the capability to mix perhaps only three different ration formulations and may have only four different market/management options for the cattle. Therefore, the feedlot must decide based on the economic value of each pen the market and ration formulation to assign to the pen. The twelve combinations of market and ration formulation may not occur in the feedlot at any one time. There also may be a dramatic difference in the numbers of pens assigned to the respective management combinations. Finally, it may be that not all of the animals are assigned to pens (and therefore management groups) based solely on their economic value.

For example, the feedlot may choose to place within a group of pens all the animals with the worst genetic combinations for meat tenderness so that these animals can be fed 240 days on feed (to a 635 kg slaughter weight) on a ration containing vitamin E, utilizing an aggressive growth promoting implant program, and then electrically stimulated and mechanically tenderized post-slaughter, with all meat except the loin going to fabricate hamburger. The remaining animals with acceptable meat tenderness genotypes may be grouped according to economic value.

Selection of management and ration formulation, as discussed above, includes predicting an amount of growth of muscle and fat tissue for each of a plurality of hypothetical rations fed for respective hypothetical periods of time, using the weight and breed data along with a biological model based on at least the genotypic profile of the subgroup. Also, each subgroup may be fed each day a ration having a quality determined by using a biological model of potential growth based on the genotypic profile of the subgroup. A net value of the subgroup may be estimated by using a bioeconomic model including a cost of fed ration, and predicted yield, quality and market price. Finally, an optimal time to send the subgroup to slaughter may be determined based on at least the net value of the subgroup estimated using the bioeconomic model.

In step 107, each subgroup is processed and marketed according to designated management group endpoint, which include, for example, (a) use of animals with genotypes leading to unacceptably tough beef for hamburger, as described above, (b) prime and tender to the Pacific Rim export market, (c) upper two-thirds of choice and tender to high end domestic steak houses, (d) bottom one-third of choice and tender to lower end steak houses and retailers as a branded product, and (e) select and tender to a branded lean and tender product.

While the invention has been described with reference to specific embodiments in detail above, the description is not meant to be construed in a limiting sense. It should be understood that the invention is not limited to the precise embodiments described herein.

For example, the terms "cattle" and "beef" as used herein are not intended to be specific to any one species or type of meat. The present invention may be practiced to manage and market fish, shrimp, pigs, chickens, lambs, and other livestock that are raised and slaughtered for consumption by humans or others.

As another example, the steps described may be taken in orders other than as described, as will be apparent to one skilled in the art after reading this disclosure, the drawings and the appended claims. The step of identifying animals having a genotype corresponding to a genetic architecture for producing unacceptably tough beef, for example, may be performed any time following birth up to the point at which the animals are grouped.

Various changes and modifications of the described embodiments could be effected by one skilled in the art without departing from the spirit or scope of the invention recited in the appended claims. Improvements and modifications which become apparent to persons of ordinary skill in the art after reading this disclosure, the drawings and the appended claims are deemed within the spirit and scope of the present invention. It is therefore contemplated that the appended claims would cover any such modifications or improvements.

What is claimed is:

1. A method of managing a group of animals comprising:

(a) determining the genotype of each animal in the group using one or more genetic markers for one or more traits selected from the group consisting of growth, quality grade, yield grade, marbling, rib-eye muscle area, dressing percentage, and meat tenderness;

(b) forming subgroups of animals according to the genotypes of the animals, wherein each animal in a subgroup has the same genetic markers; and

(c) managing the animals based on the subgroups until the animals are slaughtered.

2. A method of managing a group of animals comprising:

(a) determining the genotype of each animal in the group using one or more genetic markers for one or more traits selected from the group consisting of growth, quality grade, yield grade, marbling, rib-eye muscle area, dressing percentage, and meat tenderness;

(b) predicting an economic value for an animal according to its genotype;

(c) forming subgroups of the animals according to the predicted economic value of the animals, the animals further possessing at least one of the traits; and

(d) managing the animals based on the subgroups and/or economic value until the animals are slaughtered.

3. The method of claims 1 or 2, further comprising predicting a hypothetical muscle growth rate and fat tissue accumulation rate based on the genotype of the animals in each of the subgroups.

4. The method of claim 3, further comprising gathering weight and breed data of each animal in each subgroup at entry into a feedlot, wherein the weight and breed data are used in predicting muscle growth rate and fat tissue accumulation.

5. The method of claim 2, further comprising predicting the economic value of the animals for each of a plurality of days the animals are fed a ration.

6. The method of claim 2, further comprising predicting the economic value of the subgroups, wherein the predicted value is calculated by summing economic values of each of the animals in a subgroup, the economic values of each animal predicted for each of a plurality of days the animals are fed a ration.

7. The method of claims 1 or 2, wherein the animals are cattle.

8. The method of claims 1 or 2, wherein the genotype of each animal is determined in step (a) prior to entry of the animal into a feedlot.

9. The method of claims 1 or 2, wherein the group of traits in step (a) further consist of meat toughness, slow growth, low meat marbling content, and high meat marbling content.

10. The method of claims 1 or 2, wherein in step (c) each subgroup is rationed feed on a daily basis according to the economic value of the animals in the subgroup.

11. The method of claims 1 or 2, further comprising the step of estimating a net value of the subgroup by using a bioeconomic model including a cost of fed ration, and predicted yield, quality, and market price.

12. The method of claim 11, further comprising the step of determining an optimal time to send the subgroup to slaughter, based on at least the estimated net value of the subgroup using the bioeconomic model.

13. The method of claims 1 or 2, wherein in step (c) each subgroup is fed a ration over a plurality of days, wherein the ration and plurality of days is determined by the economic value of the subgroup.

14. The method of claims 1 or 2, wherein in step (c) animals in at least one subgroup are treated with a growth promoting implant or fed a ration with feed additives.

15. The method of claim 15, wherein the implant comprises a hormone.

16. The method of claim 15, wherein the additives are selected from the group consisting of Vitamin E, a growth promotant, and concentrated proteins.

17. The method of claims 1 or 2, wherein in step (c) animals in at least one subgroup are subjected post-slaughter to an electrical stimulation and/or a mechanical tenderization process.

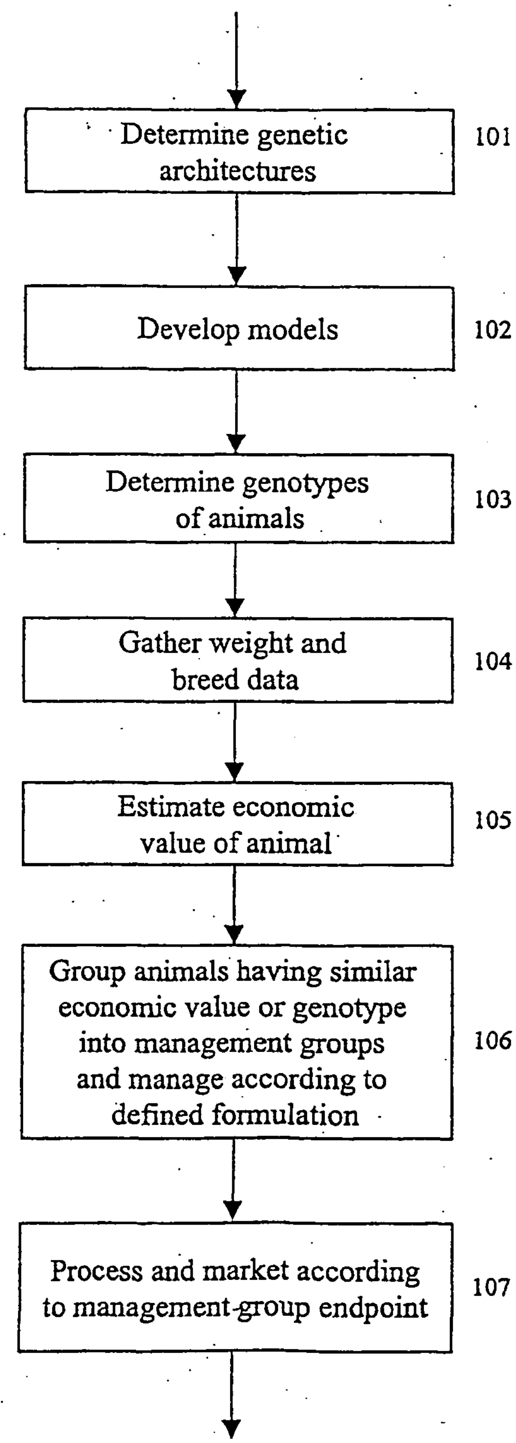
Determine genetic architectures
101
Develop models
102
Determine genotypes of animals
103
Gather weight and breed data
104
Estimate economic value of animal
105
Group animals having similar economic value or genotype into management groups and manage according to defined formulation
106
Process and market according to management-group endpoint
107

FIG. 1